

ENGINEERING-SCIENCE, INC.

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June 24, 1994

Mr. Marty Faile
AFCEE/ERT
8001 Arnold Drive
Brooks AFB, Texas 78235-5357

RE: AFCEE Bioventing Test Initiative Final Tables

Dear Marty:

Please find attached final tables and site figures for several sites at which 12 months of bioventing pilot testing have been completed. Specifically, final tables are attached for Offutt AFB sites - Building 528, Building 30, and the POL Storage Area; Whiteman AFB - Aboveground Soil Pile; Kirtland AFB - Site FT-13; and Kelly AFB - Site S-4.

Only one table is included for the Whiteman AFB Aboveground Soil Pile. Oxygen concentrations in soil gas in the soil pile remained near atmospheric for the duration of the pilot test and therefore, no respiration tests were performed. Based on the nature of the soil, a silty clay, and contaminant distribution, ES recommends the soil pile be mixed with a bulking agent such as wood chips or straw. Mixing would homogenize the soil which consists of clods of silty clay that are typically heterogeneously contaminated. Mixing would distribute the petroleum hydrocarbons through out the soil creating more surface area for biodegradation processes. The bulking agent would create voids spaces to ensure adequate supply of oxygen and allow drainage of excess moisture from the pile. Based on observed soil gas conditions, the passive aeration design that is currently in place should be adequate to maintain sufficient oxygen concentrations. However, if a bulking agent is added and/or the pile is homogenized, further soil gas surveys are recommended to monitor oxygen concentrations.

Please call me or Doug Downey at (303) 831-8100 if you have any questions.

Sincerely,

ENGINEERING-SCIENCE, INC.

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Distribution Unlimited



Brian Blicker
Environmental Engineer

c.c.: Doug Downey
File

DATE OF PUBLIC RELEASE: 4

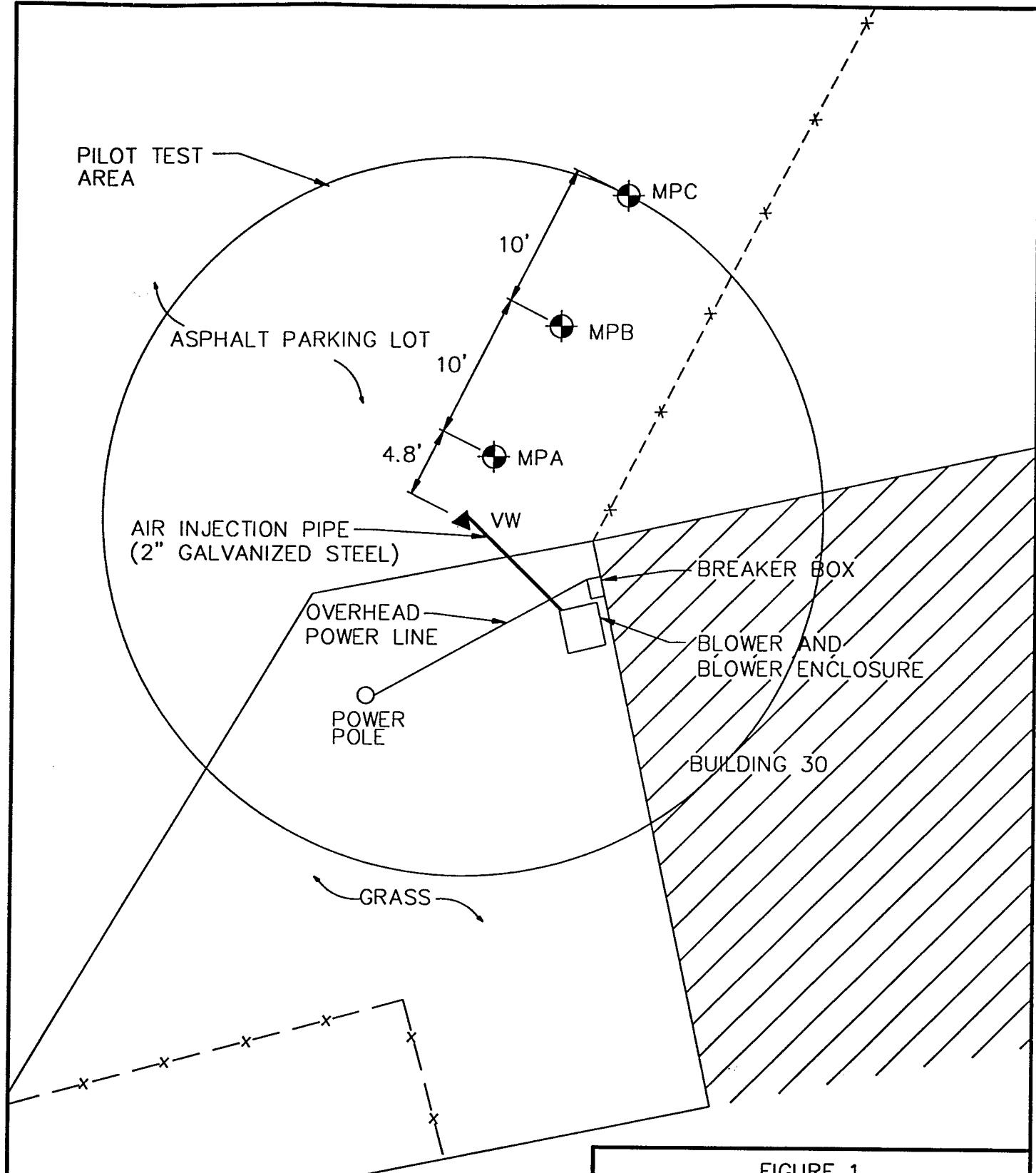


FIGURE 1

AS-BUILT VENT WELL,
MONITORING POINT AND
BLOWER LOCATIONS
BUILDING 30

OFFUTT AFB, NEBRASKA

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

LEGEND



VAPOR MONITORING
POINT



VENT WELL

0

10

20

FEET

TABLE 1
BUILDING 30
RESPIRATION AND DEGRADATION RATES
OFFUTT AFB, NEBRASKA

Location-Depth	K_o (% O ₂ /min)	Initial Degradation Rate (mg/kg/year) ^a	Soil Temperature (°C)	K_o (% O ₂ /min)	6-Month ^b		Soil Temperature (°C)	K_o (% O ₂ /min)	1-Year	
					Degradation Rate (mg/kg/year)	NS ^c			Degradation Rate (mg/kg/year)	1-Year Degradation Rate (mg/kg/year)
VW	0.00090	180	NS ^c	NS	NS	NS	NS	0.00042	100	NS
MPA-4.5	NS	NS	8.06	0.00013	29	15.5	NS	NS	NS	6.50
MPA-9.5	NS	NS	8.11	NS	NS	16.8	NS	NS	NS	8.06
MPB-9.5	0.069	16,000	NS	0.0013	310	2.56	0.00052	120	NS	
MPC-5	0.12	27,000	NS	0.00036	83	NS	NS	NS	NS	NS
MPC-9.5	0.14	31,600	NS	0.0016	360	NS	0.0010	240	NS	NS

^a/ Milligrams hydrocarbons per kilogram soil per year

^b/ Moisture content an average of initial and final readings.

^c/ NS = Not Sampled.

REV01:6/20/94

TABLE 2
BUILDING 30
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
OFFUTT AFB, NEBRASKA

Analyte (Units) ^{a/}	Sample Location-Depth (feet below ground surface)					
	VW		MPB-9.5		MPC-9.5	
Soil Gas Hydrocarbons	Initial ^{b/}	1-Year ^{c/}	Initial	1-Year	Initial	1-Year
TVH (ppmv)	1,500	220	15,000	92	8,000	190
Benzene (ppmv)	<0.10	<0.005	<2.1	<0.005	<0.35	<0.005
Toluene (ppmv)	<0.10	<0.005	<2.1	<0.005	<0.35	<0.005
Ethylbenzene (ppmv)	<0.10	<0.005	<2.1	<0.005	<0.35	<0.005
Xylenes (ppmv)	<0.10	<0.005	3.2	<0.005	0.91	<0.005
Soil Hydrocarbons	VW-10		MPA-8		MPB-8	
	Initial ^{d/}	1-Year ^{e/}	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	<6.7	<6.1	<6.7	<6.5	13	<6.4
Benzene (mg/kg)	<0.00027	<0.0006	<0.00027	<0.0006	<0.00026	<0.0006
Toluene (mg/kg)	0.0055	0.0010	0.00074	<0.0006	0.0024	0.011
Ethylbenzene (mg/kg)	<0.00020	<0.0006	<0.0002	<0.0006	<0.0002	<0.0006
Xylenes (mg/kg)	0.037	0.0010	0.0023	<0.0006	0.0028	<0.0006
Moisture (% by wt.)	25	21.7	25	23.1	23	22.5

^{a/} TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram;

TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;

CaCO₃=calcium carbonate; TKN=total Kjeldahl nitrogen.

^{b/} Initial soil gas samples collected on 05/01/93.

^{c/} 1-Year soil gas samples collected on 04/08/94.

^{d/} Initial soil samples collected on 4/27/93 AND 4/28/93.

^{e/} 1-Year soil samples collected on 4/12/94.

LEGEND

	UST
	INJECTION WELL
	MONITORING POINT
	POWER POLE

LPD-MW1 EXISTING MONITORING WELL

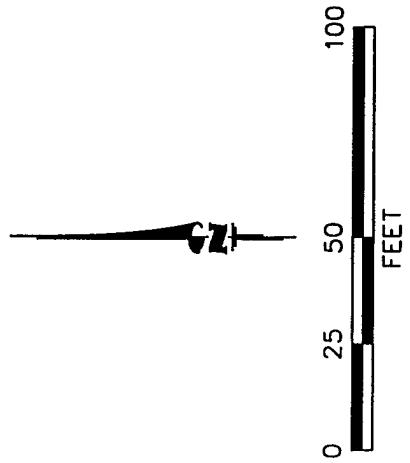
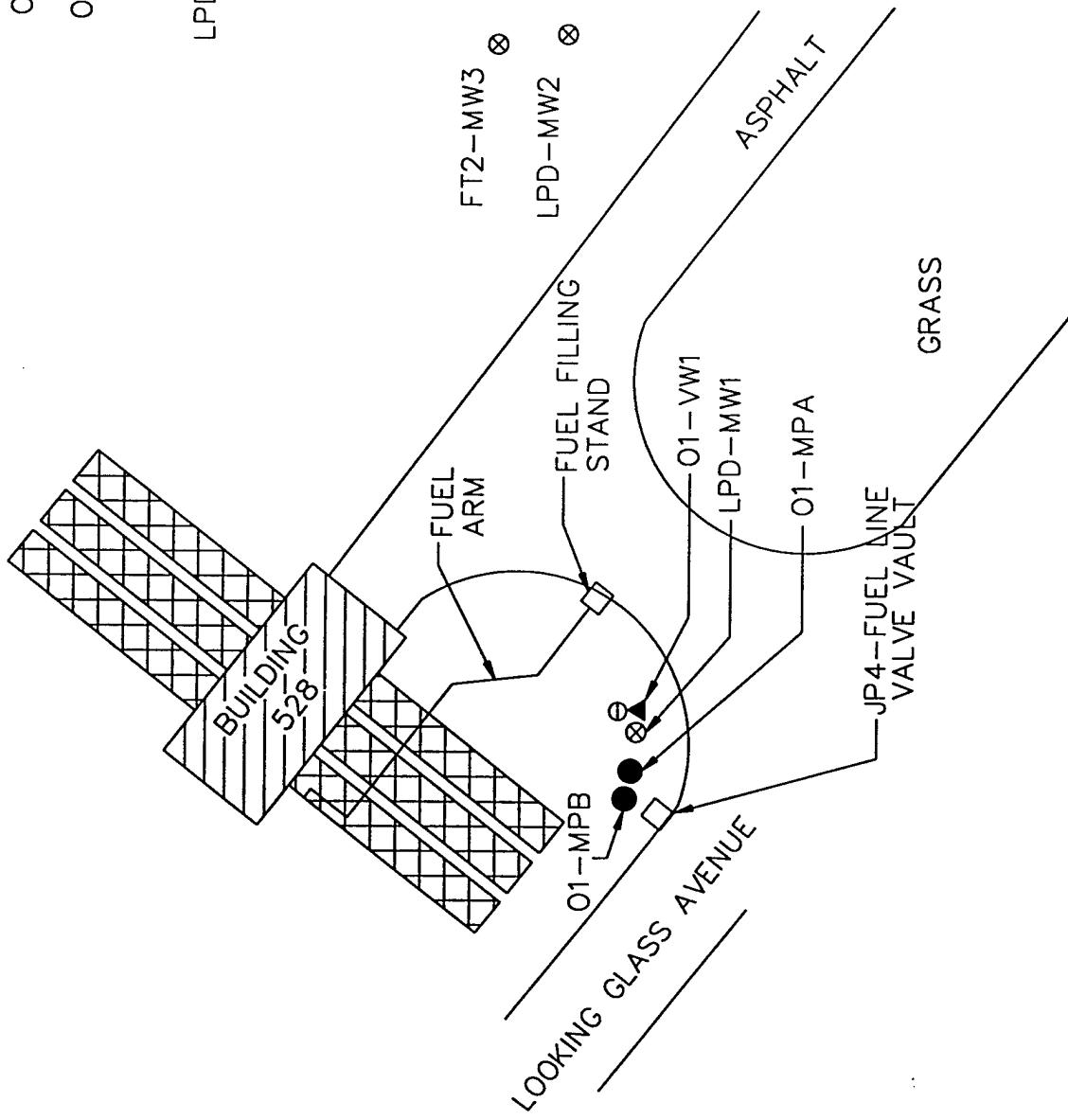


FIGURE 1

VENT WELL, MONITORING POINT
AND BLOWER LOCATIONS
BUILDING 528

OFFUTT A.F.B., NEBRASKA

ENGINEERING-SCIENCE, INC.
Denver, Colorado

TABLE 1
BUILDING 528
RESPIRATION AND DEGRADATION RATES
OFFUTT AFB, NEBRASKA

Location - Depth	Initial		6-Month ^{b/}		1-Year				
	K _{O₂} (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	Soil Temperature (°C)	K _{O₂} (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _{O₂} (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW1	0.015	4,200	NS	NS ^{c/}	NS	NS	NS	NS	NS
MW1	0.018	5,000	NS	0.00058	230	NS	0.0040	1,000	NS
MPA-4	NS	NS	NS	0.0011	430	NS	0.000031	7.0	NS
MPA-7	0.011	3,100	NS	0.00099	390	NS	NS	NS	NS
MPB-4	NS	NS	21.6	0.0042	1500	NS	0.0021	550	5.50
MPB-7	0.013	3,700	20.0	0.0064	2300	NS	NS	NS	5.00

^{a/} Milligrams hydrocarbons per kilogram soil per year

^{b/} Moisture content an average of initial and final readings.

^{c/} NS = Not Sampled.

REV016/20/94

TABLE 2
BUILDING 528 – LOW POINT DRAIN
INITIAL AND 1–YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
OFFUTT AFB, NEBRASKA

Analyte (Units) ^{a/}	Sample Location–Depth (feet below ground surface)					
	VW		LPD–MW1		MPB–7	MPB–4
Soil Gas Hydrocarbons	Initial ^{b/}	1–Year ^{c/}	Initial	1–Year	Initial	1–Year
TVH (ppmv)	35,000	5.8	25,000	3,700	28,000	6,300
Benzene (ppmv)	38	0.054	34	<0.21	140	<0.17
Toluene (ppmv)	210	0.018	170	<0.21	110	<0.17
Ethylbenzene (ppmv)	62	0.022	62	<0.21	49	<0.17
Xylenes (ppmv)	140	0.041	31	<0.21	11	<0.17
Soil Hydrocarbons	VW–4	VW–7	MPA–7		MPB–7	
	Initial ^{d/}	1–Year ^{e/}	Initial	1–Year	Initial	1–Year
TRPH (mg/kg)	37	<6.3	6.0	<6.6	10	140
Benzene (mg/kg)	<0.740	<0.0006	0.030	<0.0033	0.034	0.0015
Toluene (mg/kg)	2.0	0.0017	0.019	0.0036	0.030	0.0032
Ethylbenzene (mg/kg)	2.7	0.0055	0.0050	0.0058	<0.0028	0.0044
Xylenes (mg/kg)	8.8	0.026	0.015	0.03	0.026	0.028
Moisture (% by wt.)	19.4	21	14.9	24	9.5	21

^{a/} TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram;

TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;

CaCO₃=calcium carbonate; TKN=total Kjeldahl nitrogen.

^{b/} Initial soil gas samples collected on 08/14/92.

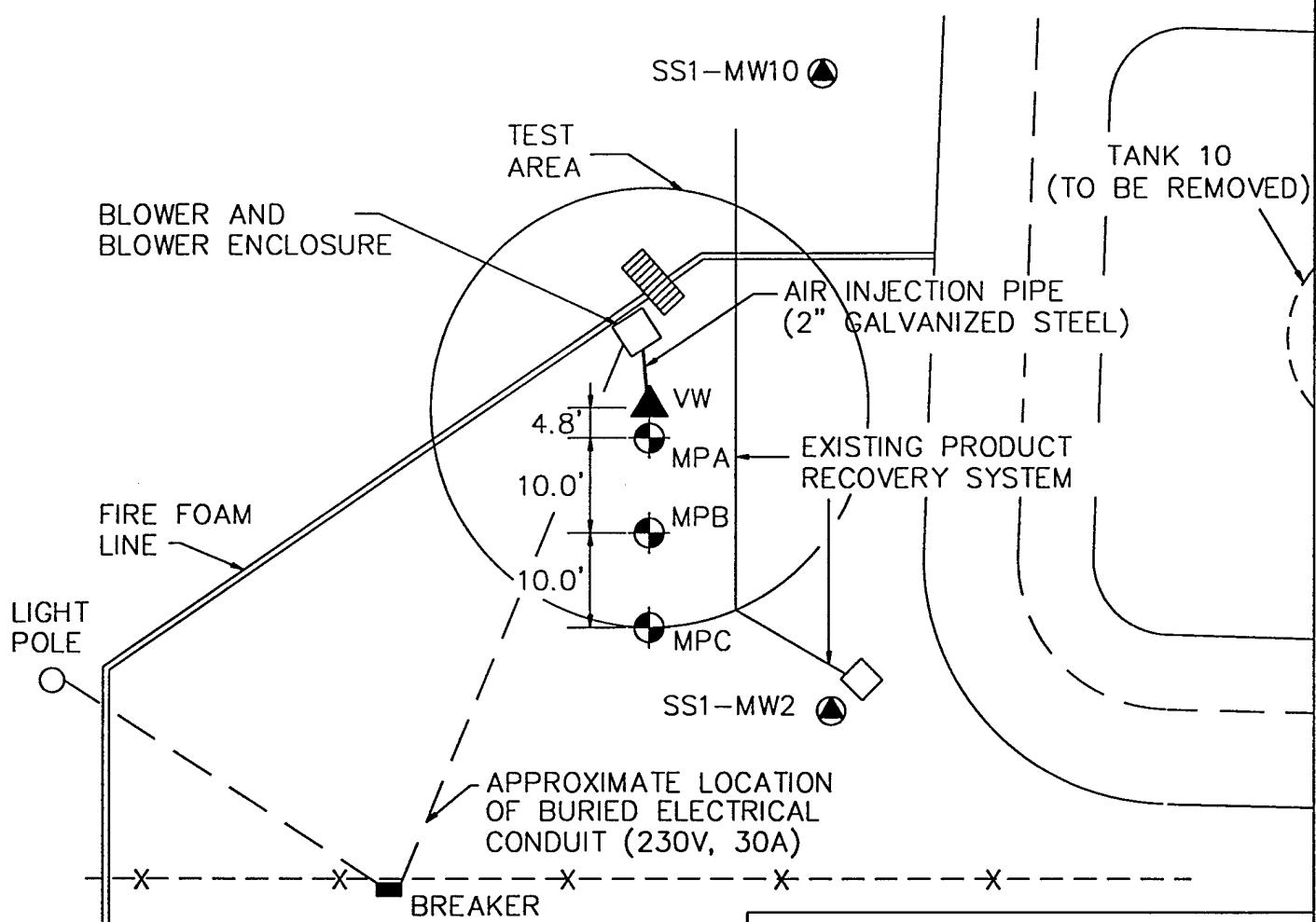
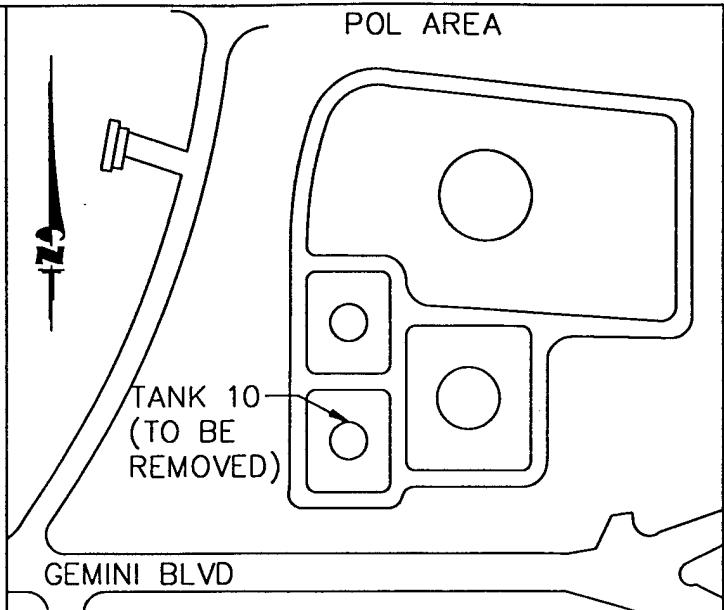
^{c/} 1–Year soil gas samples collected on 04/07/94 AND 04/08/94.

^{d/} Initial soil samples collected on 08/12/92.

^{e/} 1–Year soil samples collected on 10/23/93.

LEGEND

- SS1-MW2 EXISTING MONITORING WELL
● VAPOR MONITORING POINT
▲ VENT WELL
—X— FENCE



0 10 20 40
FEET

FIGURE 1
AS-BUILT VENT WELL,
MONITORING POINT,
AND BLOWER LOCATIONS
POL STORAGE AREA
OFFUTT AFB, NEBRASKA
ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

TABLE 1
POL STORAGE AREA
RESPIRATION AND DEGRADATION RATES
OFFUTT AFB, NEBRASKA

Location-Depth	Initial			6-Month ^{b/}			1-Year		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW	0.033	7,100	NS ^{c/}	NS	NS	NS	0.0077	5,100	NS
MPA-4	NS	NS	6.94	NS	NS	NS	NS	NS	6.50
MPA-7	NS	NS	8.22	NS	NS	NS	0.0075	5,000	6.67
MPC-4	0.0013	260	NS	NS	NS	NS	NS	NS	NS

^{a/} Milligrams hydrocarbons per kilogram soil per year

^{b/} Six month test not conducted as all monitoring points were below ground water.

^{c/} NS = Not Sampled.

REV01:6/17/94

TABLE 2
POL STORAGE AREA
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
OFFUTT AFB, NEBRASKA

Analyte (Units) ^{a/}	Sample Location—Depth (feet below ground surface)					
	VW-3		MPC-4		MPA-7	
Soil Gas Hydrocarbons	Initial ^{b/}	1-Year ^{c/}	Initial	1-Year	Initial	1-Year
TVH (ppmv)	130	620	1,000	NS ^{d/}	NS	1,100
Benzene (ppmv)	130	<0.026	3.6	NS	NS	<0.017
Toluene (ppmv)	21	<0.026	1.9	NS	NS	<0.017
Ethylbenzene (ppmv)	7.0	<0.026	0.9	NS	NS	<0.017
Xylenes (ppmv)	17	0.72	2.0	NS	NS	<0.017
Soil Hydrocarbons	VW-3		MPA-3		MPB-3	
	Initial ^{e/}	1-Year ^{f/}	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	6.5	7.1	<6.3	6.2	<6.3	<6.3
Benzene (mg/kg)	0.0041	<0.00070	0.075	<0.0006	0.0011	<0.00060
Toluene (mg/kg)	<0.00025	<0.00070	0.0022	<0.0006	<0.00025	<0.00060
Ethylbenzene (mg/kg)	<0.00018	<0.00070	0.053	0.0045	0.0049	0.0070
Xylenes (mg/kg)	<0.00063	<0.00090	0.082	0.012	0.0020	0.0095
Moisture (% by wt.)	18	24.8	20	17.2	19	21.2

^{a/} TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram;

TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;

CaCO₃=calcium carbonate; TKN=total Kjeldahl nitrogen.

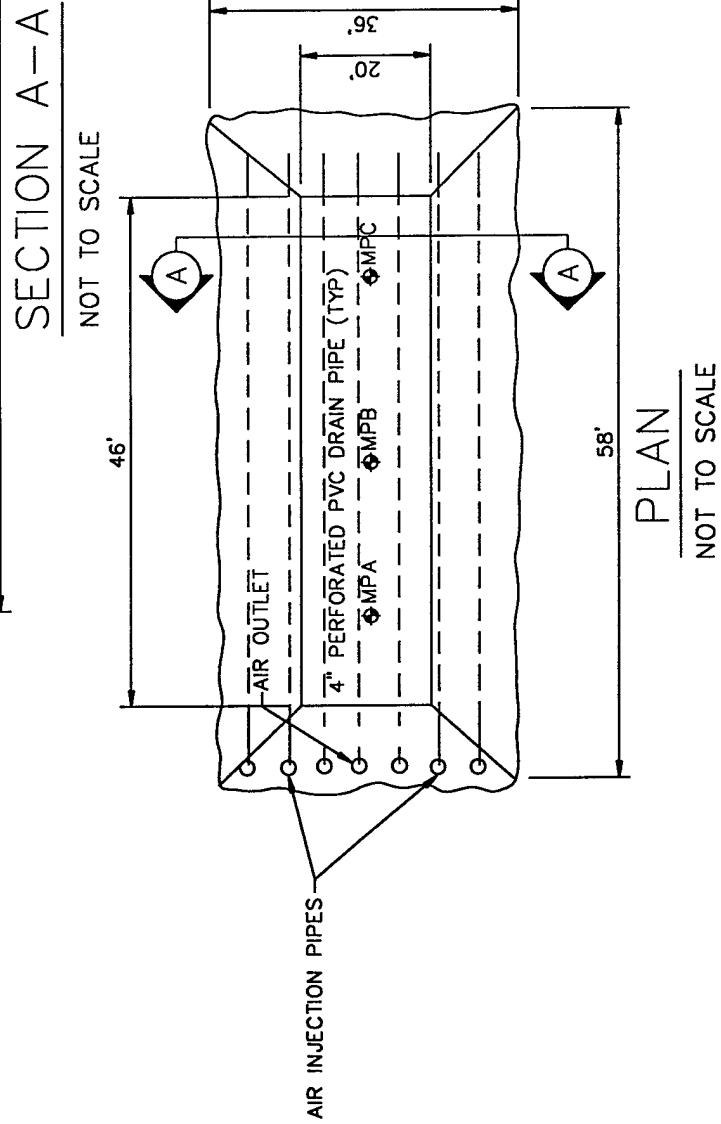
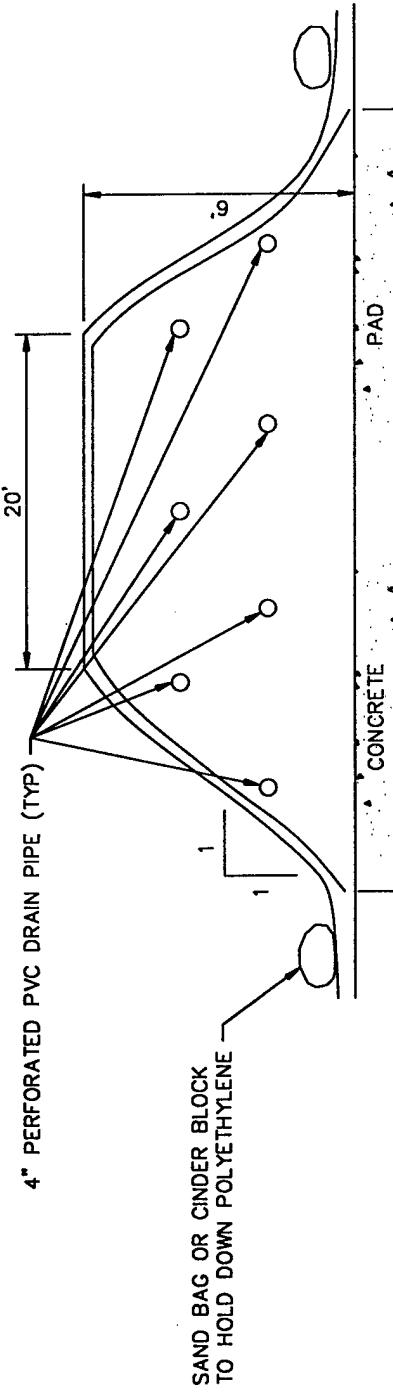
^{b/} Initial soil gas samples collected on 05/01/93.

^{c/} 1-Year soil gas samples collected on 04/07/94.

^{d/} NS = Not sampled due to saturated soil conditions.

^{e/} Initial soil samples collected on 04/29/93.

^{f/} 1-Year soil samples collected on 04/11/94.



LEGEND

♦ MPA MONITORING POINT

♦ MPC

ABOVEGROUND SOIL PILE
AS-BUILT CONSTRUCTION
DETAIL

FIGURE 1

WHITEMAN AFB, MISSOURI
ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

TABLE 1
ABOVEGROUND SOIL PILE
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
WHITEMAN AFB, MISSOURI

Analyte (Units) ^a	Sample Location—Depth (feet below ground surface)					
	MPA—4.5		MPB—4.5		MPC—4.5	
Soil Gas Hydrocarbons	Initial	1-Year	Initial	1-Year	Initial	1-Year
TVH (ppmv)	NS ^b	NS	NS	NS	NS	NS
Benzene (ppmv)	NS	NS	NS	NS	NS	NS
Toluene (ppmv)	NS	NS	NS	NS	NS	NS
Ethylbenzene (ppmv)	NS	NS	NS	NS	NS	NS
Xylenes (ppmv)	NS	NS	NS	NS	NS	NS
Soil Hydrocarbons	MPA		MPB		MPC	
	Initial ^c	1-Year ^d	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	5,245	638	3,236	1,400	396	196
Benzene (mg/kg)	<0.00375	<0.15	NS	<0.079	NS	<0.077
Toluene (mg/kg)	<0.003	<0.15	NS	<0.079	NS	0.22
Ethylbenzene (mg/kg)	0.0055	<0.15	NS	<0.079	NS	<0.077
Xylenes (mg/kg)	0.012	<0.21	NS	<0.11	NS	0.20
Moisture (%)	20.34	17.3	15.24	20.6	17.96	18.9
Temperature (°C)	NS	NS	NS	NS	9.83	7.83

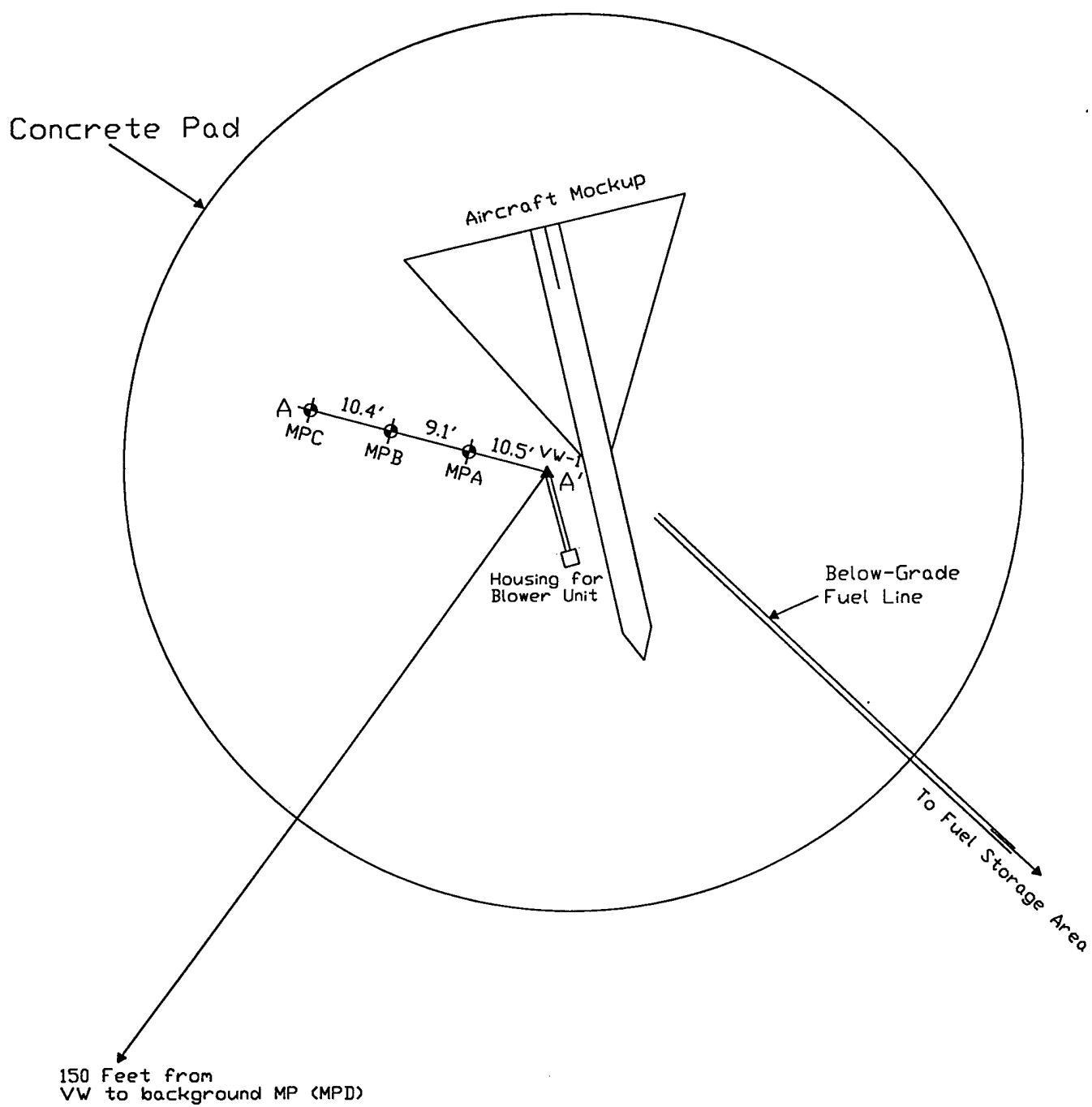
^a/TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;

TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^b/NS = Not sampled.

^c/Initial soil samples were collected on April 19 and 20, 1993. The sample from MPA was taken from 4 feet below the top of the soil pile, samples from MPB and MPC were composite samples from the top of the pile to 5 feet below the top of the pile.

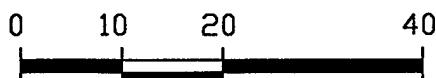
^d/Final soil samples were collected on April 6, 1994. Samples from MPA and MPB were composites from the top of the soil pile to 5 feet below the top of the pile. The sample from MPC was taken from 4 feet below the top of the pile.



LEGEND

- ▲ Vent Well (Air Injection)
- ◆ Vapor Monitoring Point

A - A' Location of Geologic Section



SCALE: 1" = 20'

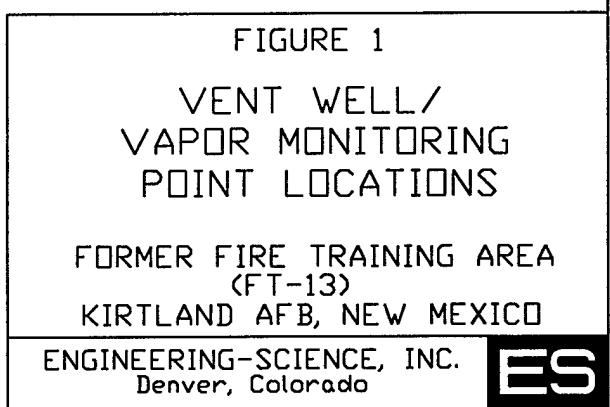


TABLE 1
SITE FT-13
RESPIRATION AND DEGRADATION RATES
KIRTLAND AFB, NEW MEXICO

Location-Depth	Initial (Apr. 1993)		3-Month (Jun. 1993)		Soil Temperature (°C)		6-Month (Nov. 1993)	
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^a	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^b	(% O ₂ /min)	Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^b
VW-1 (5-30)	0.0012	300	NS ^c	0.00014	34	NS	0.00014	34
MPA-6	NS	NS	12.0	NS	NS	20.4	NS	NS
MPA-15	0.0011	280 ^d	NS	0.00014	34 ^d	NS	0.00015	37 ^d
MPA-24	0.00058	140 ^d	16.3	NS	NS	14.6	NS	NS
MPB-24	0.00088	220 ^d	NS	0.00017	42 ^d	NS	0.00010	25 ^d
MPC-24	0.0013	310 ^d	NS	0.00034	84 ^d	NS	0.00016	39 ^d

Location-Depth	9-Month (Feb. 1994)		Soil Temperature (°C)		12-Month (May 1994)	
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^b	(% O ₂ /min)	Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)
VW-1 (5-30)	0.000059	15	NS	0.000030	74	NS
MPA-6	NS	NS	10.3	NS	NS	15.8
MPA-15	0.00014	34 ^d	NS	0.000094	23 ^d	NS
MPA-24	NS	NS	14.4	NS	NS	14.7
MPB-24	0.000069	17 ^d	NS	0.000062	15 ^d	NS
MPC-24	0.000096	24 ^d	NS	0.000099	24 ^d	NS

^a Milligrams of hydrocarbons per kilogram of soil per year

^b Assumes moisture content of the soil is average of initial and final moistures.

^c NS=Not Sampled.

TABLE 2
SITE FT-13
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
KIRTLAND AFB, NEW MEXICO

Analyte (Units) ^{a/}	Sample Location (Depth, feet below ground surface)							
	VW1 (5-30)		MPA-15		MPC-24			
	Initial ^{b/}	1-Year ^{c/}	Initial	1-Year	Initial	1-Year	Initial	1-Year
Soil Gas Hydrocarbons								
TVH (ppmv)	870	15	16000	550	22000	1500		
Benzene (ppmv)	0.63	<0.002	45	<0.013	12	0.024		
Toluene (ppmv)	5.7	<0.002	110	<0.013	53	<0.016		
Ethylbenzene (ppmv)	1.8	0.008	9.1	0.195	14	0.11		
Xylenes (ppmv)	7.2	0.037	33	0.45	63	1.2		
Soil Hydrocarbons								
	VW1 (15-17)		MPA (2-4)		MPB (5-7)		MPC (10-12)	
	Initial ^{d/}	1-Year ^{e/}	Initial	1-Year	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	6534	8850	1200	6490	1338	3750	<4.0	6.7
Benzene (mg/kg)	<3.0	<0.14	<0.83	<0.14	<3.1	<.074	<0.002	<0.0005
Toluene (mg/kg)	13	4.9	3.4	3.2	20	0.80	0.007	<0.0005
Ethylbenzene (mg/kg)	18	3.9	5.8	13	14	12	<0.002	0.0005
Xylenes (mg/kg)	110	20	38	97	80	33	0.012	0.0030
Moisture (%)								
	7.6	7.8	16.1	10.6	10.7	15.0	10.4	12.2

^{a/}TVH = total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH = total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.

^{b/} Initial soil gas samples collected on 4/7/93.

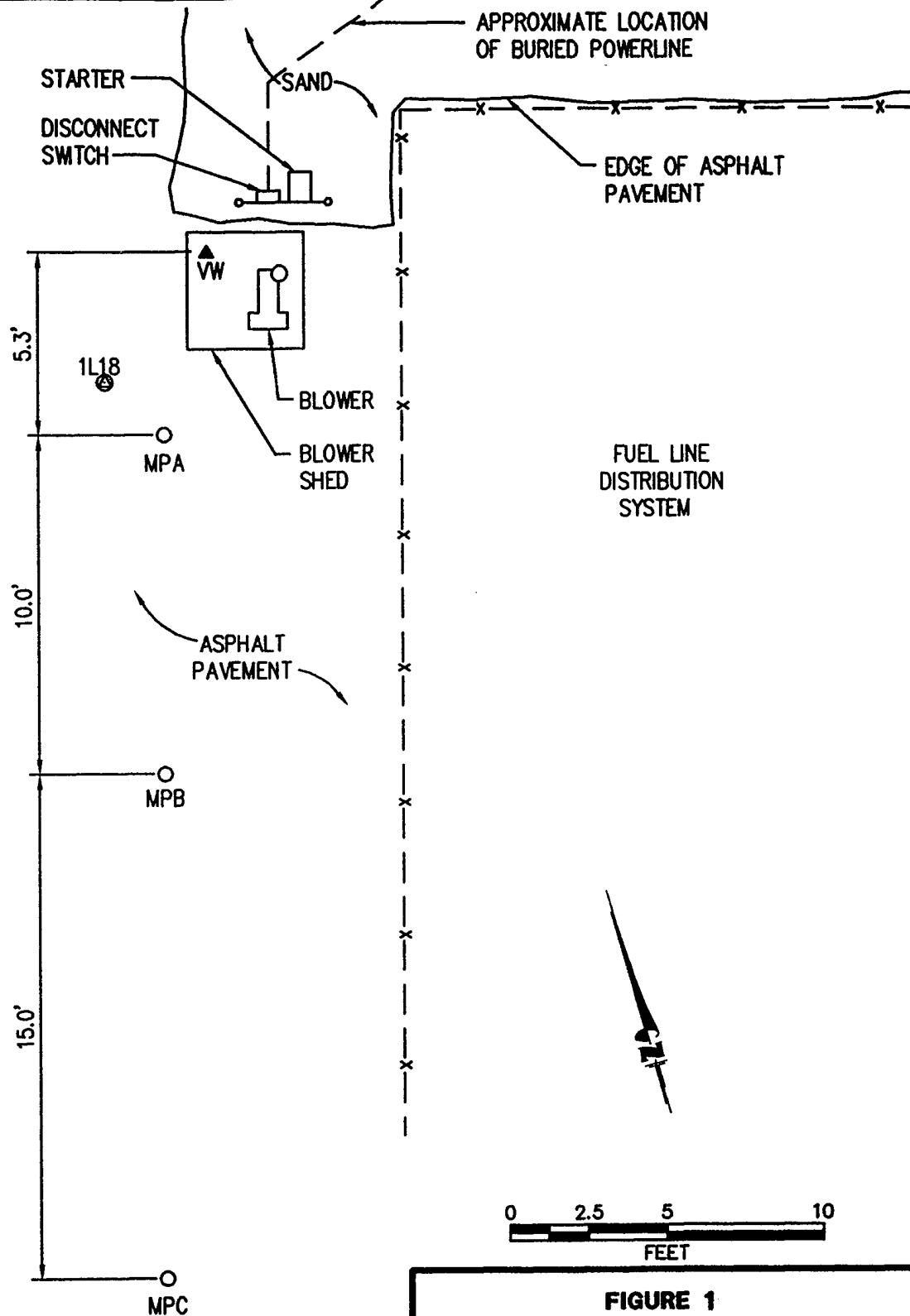
^{c/} 1-Year soil gas samples collected on 5/24/94 and 5/25/94.

^{d/} Initial soil samples collected on 4/5/93 and 4/6/93.

^{e/} 1-Year soil samples collected on 5/24/94.

^{f/} NS=Not Sampled.

BERMAN ROAD



LEGEND

- ▲ INJECTION VENT WELL
- MONITORING POINT
- ◎ EXISTING GROUNDWATER MONITORING WELL
- X — FENCE

**SITE S-4
AS-BUILT SITE PLAN**

KELLY AFB, TEXAS

ENGINEERING-SCIENCE, INC.
Denver, Colorado

TABLE 1
SITE S-4
RESPIRATION AND DEGRADATION RATES
KELLY AFB, TEXAS

Location-Depth, feet bgs	Initial = December 1992		6-Month = June 1993		1-Year = January 1994				
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^a	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate ^b (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW-7-17	.041	12000	NS ^c	.0013	290	NS	NS	NS	NS
MPA-5	NS	NS	20.4	NS	NS	27.4	NS	NS	18.2
MPA-12.5	.046	1900	23.2	.0041	210	25.2	.0021	160	24.4
MPB-9	.033	9800 ^d	NS	.0019	420 ^d	NS	.0011	160 ^d	NS
MPB-12.5	.035	5500	NS	.0054	900	NS	.0026	430	NS
MPC-9	NS	NS	NS	.0033	740 ^d	NS	.0018	260 ^d	NS
MPC-12.5	.042	7900 ^e	NS	.012	2200 ^e	NS	NS	NS	NS

^a/ Milligrams of hydrocarbons per kilogram of soil per year.

^b/ Assumes moisture content of the soil is average of initial and final moistures.

^c/ NS=Not Sampled.

^d/ Degradation rate calculated assuming MPB-9 and MPC-9 soil moisture content the same as VW.

^e/ Degradation rate calculated assuming MPC-12.5 soil moisture content the same as MPB-12.5.

TABLE 2
SITE S-4
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
KELLY AFB, TEXAS

Analyte (Units) ^{a/}	Sample Location—Depth (feet below ground surface)					
	VW (7-17)		MPA-12.5		MPC-12.5	
	Initial ^{b/}	1-Year ^{c/}	Initial	1-Year	Initial	1-Year ^{d/}
Soil Gas Hydrocarbons						
TVH (ppmv)	29500	23	16,000	52	64,000	1,200
Benzene (ppmv)	130	.044	50	0.028	420	<.10
Toluene (ppmv)	18.5	.035	7.7	0.410	39	2.20
Ethylbenzene (ppmv)	20.5	.019	<3.5	0.140	45	0.75
Xylenes (ppmv)	17.5	.041	<3.5	0.450	39	1.40
Soil Hydrocarbons						
TRPH (mg/kg)	1600	131	56	658.0	1,100	985.0
Benzene (mg/kg)	<.35	<.08	<.42	<.084	<.76	<.078
Toluene (mg/kg)	11.0	.41	5.3	0.52	11.0	1.9
Ethylbenzene (mg/kg)	<.29	<.08	<.35	<.084	<.63	<.078
Xylenes (mg/kg)	16.0	.11	11.0	2.6	13.0	1.8
Moisture (%)	13.9	22.0	28.3	26.2	21.0	20.5

^{a/} TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;

TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/} Initial soil gas samples collected on 12/14/92.

^{c/} 1-Year soil gas samples collected on 1/21/94.

^{d/} 1-Year soil gas for MPC was collected from MPC-9.

^{e/} Initial soil samples collected on 12/10/92 and 12/11/92.

^{f/} 1-Year soil sample for vent well collected on 5/18/94.

^{g/} 1-Year soil samples for monitoring points collected on 1/8/94.